CLIMATE VARIABILITY AND WATER YIELD IN OBUDU LOCAL GOVERNMENT AREA, CROSS RIVER STATE, NIGERIA.

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ABSTRACT

One of the most important aspects of weather and climate is its variability. This variability ranges over different time scales, resulting to wind gust, localized thunder storms, tornadoes, storms, drought and floods. This study is aimed at examining climate variability on water yield in River Abeb, Obudu Local Government Area of Cross River State, Nigeria. To achieve this, data on annual rainfall, evaporation, temperature and water yield were collected from NIMET at the Obudu Dam station for a period of twenty (20) years. The data were analyzed using correlation and multiple regression models. The result shows that temperature had a standard deviation of 1.2% and mean of 33.4º C, while evaporation had a standard deviation of 9.08 with mean of 46.7mm and coefficient of variation of 5% within the same period under review. The results further revealed that rainfall correlated very high with r-value of 0.95, temperature correlated very low with r-value of 0.20 while evaporation correlated negatively with r-value of -0.23. The degree of variation for each climate parameter had a mean value of 2053.99mm for rainfall between 1993-2012, with standard deviation of 504.68, 26% coefficient of variation. Temperature had a standard deviation of 1.2% and mean of 33.4° C, while evaporation had a standard deviation of 9.08 with mean of 46.7mm and coefficient of variation of 5% within the same period under review. The result of the regression model showed a coefficient of determination of R^2 of 92% which implies that 92% of changes in water yield in River Abeb is accounted for by climate parameters (rainfall, temperature and evaporation). The study also revealed a significant variation in rainfall amount within the period under review. It is therefore recommended that intensive trees planting be carried out around River Abeb catchment to moderate the micro climate in the area.

Keywords : Climate, variability ,water yield , Obudu.

INTRODUCTION

In recent times, global climate has exhibited a wide range of variability characterized by increasing temperature as well as unpredictable rainfall conditions in different parts of the globe. These unfolding weather conditions are already having some kind of impact on the environment. In some areas, the environment is becoming increasingly dryer while in other areas it is becoming wetter (Iguisi & Awwal, 2008).

One of the most important aspects of our weather and climate is its variability. This variability ranges over different time scales, from small scale phenomena such as wind gust, localized thunderstorms and tornadoes to large-scale features such as fronts and storms, to even more prolonged features such as droughts and floods, and to fluctuations occurring on daily, weekly, monthly, yearly, seasonal, and decadal timescales. According to Ayade (2004), climate variability simply refers to shorter term (daily, seasonal, annual, inter-annual, several years) variations in climate, including the fluctuations associated with El Nino (dry) and La Nina (wet) events.

On the temporal climate scale, climate variability can be examined for periods ranging from one day, one month, and one year to a few years. Therefore, short-terms climate variability seems to be the major source of contemporary climate impact and will likely remain so in the foreseeable future (Ekpoh, 2009). Climate is a fundamental driver of the hydrological cycle therefore; there is a strong correlation between climate variability and water availability.

Nigeria is blessed with abundance of water resources, however, the water is not evenly distributed across the country and water availability varies spatio-temporally. As a result, most regions of the country have experienced water related problems such as shortage and inadequate supply (IPCC, 2008). Communities in the high lands of Obudu on the south eastern flanks of Nigeria have reported these. Most of Nigeria's food production is in the savannah and this is mostly rain-fed. This also puts pressure on livestock production systems, human health management and settlement patterns. Obudu is very susceptible to climate variability due to her physical location and characteristics as well as socio economic status (Chinedum , 2011).

Most rivers in this basin catchment are influenced by rainfall regime which also determined the volume of rainfall incident on the catchment areas of these rivers. Therefore, declining rainfall is bound to have a negative effect on water yield (Iguisi & Awal, 2008). After the 1973 sahelian drought in Nigeria which devastated extensive lives and properties, the Federal Government embarked on massive Dam construction as a way of providing alternative sources of water for domestic and Agriculture projects in the country. Under the scheme, several dams were expected to alleviate water scarcity for domestic and Agricultural projects in Nigeria. Under the scheme, several

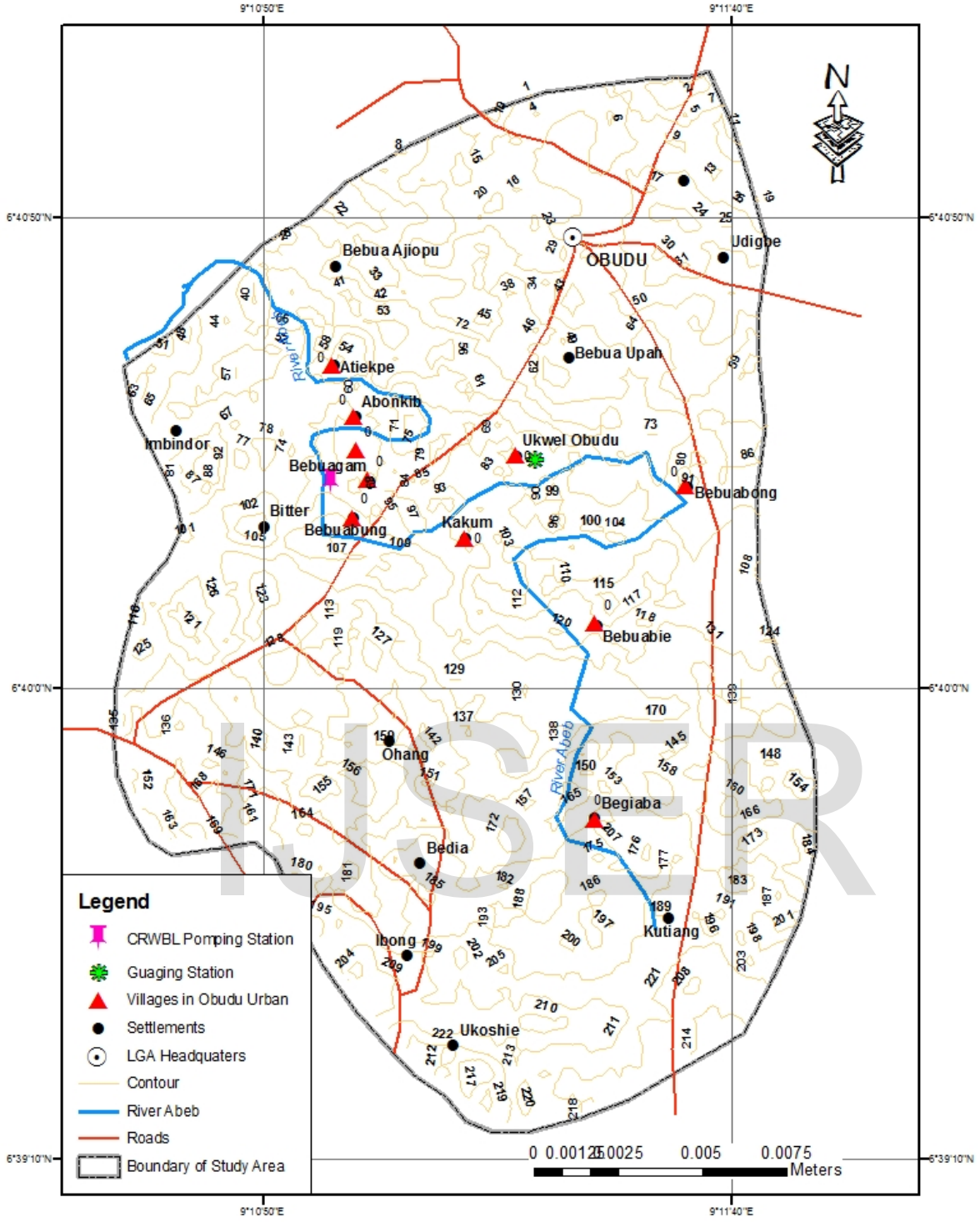
dams were built and were expected to alleviate water scarcity for domestic and agricultural purposes. The dam project culminated in the establishment of the River Basin Development Authority across the country by Degree 25 of 1975 by the then military Government of Nigeria. During the 1973 drought, 300,000 animals representing about 13 percent of the total livestock population of Bauchi, Borno and the then Gongola states perished (Joshua& Ekwe, 2013). These rivers were fed and sustained by rainfall. Water yield in these surface streams and rivers were determined by the volume of rainfall incident on the catchment areas (Utang, Akintoye &Wilcox, 2008). Today , a declining trend in the rainfall in Obudu is having negative effects on the water yield in River Abeb.

Obudu urban water supply scheme relies on surface water from River Abeb with the Obudu dam complimenting it. The flow regime of River Abeb and its tributaries suffer from seasonal fluctuation. This river has continued to dwindle in volume, with serious threat to water supply in Obudu (Esu, Okereke, Edet & Okueze, 1996). Unfortunately, little studies have attempted to examine the impact of climate variability on water yield in River Abeb in relation to the observed reduction in it volume and size. If adequate steps are not taken in the right direction, this may lead to severe water scarcity with River Abeb not being able to cater for the teeming population of Obudu, hence the thrust of this research.

Materials and methods

Study Area

Obudu Local Government Area is located in the northern part of Cross River State. It lies between longitude 8° 55'E and 9° 10'E and latitude 6° 22'N and 6°40'N. Bounded in the North by Benue State, in the south by Boki Local Government Area, in the East by Obanliku Local Government Area, and in the West by Bekwara and Ogoja Local Government Areas (Cross River State Department of Planning, Research and Statistics, 2008). It lies in a mountainous area just north of the Cross River National park with an altitude of about 5,000ft (Abua & Ajake, 2015) (fig.1).



Source: Geographic Information System (GIS) Laboratory, Department of Geography and Environmental Science, University of Calabar.

FIG. 1:The Catchment area of River Abeb

Obudu climate falls into the tropical monsoon category. Obudu experiences orographic rainfall between 1200-2000mm annually. Mountains form barriers over which air flows, rises and cools adiabatically to the dew point and condensation occurs, causing orographic precipitation on the windward slope (Ekpoh , 2009). The region is characterized with seasonal fluctuations of rainfall regime throughout the year. This rainfall pattern influences human activities in Obudu. The temperature regime is also affected by the relief structure of Kutiang and the surrounding mountains (Abua, 2017; Abua & Digha, 2015).

River Abeb has its source from Kutiang mountain which is described by the local people as Lishi-abeb (in other words, head water). This mountain saves as watershed. The draining network indicates that the dentritic catchment is typically of the dentritic pattern with a high network of 1st to 3rd order tributary that concentrated more in the upstream of the southern –eastern flank. The flow regime of River Abeb system follows the rainfall regime of the region (Abua & Abua, 2013).

Abeb is the major river that traverse the entire area and links to river Aya system to become its major tributary. Most of the tributaries of river Abeb are intermittent in nature such as the Akamba and Ugwu-Bebia. These streams have low flow regime that reflects the description that river regime of small and moderately sized basins closely reflect the climate controls (Beckinsale, 1978 in Chorley, 1971).

Data Collection

Data on climate parameters were obtained from Nigeria Meteorological Agency (NIMET), while data on water yield were obtained from Cross River Basin Development Authority. NIMET employed standard rain gauge in obtaining rainfall in millimeters on daily basis. Temperature was measured using maximum and minimum thermometer in degree Celsius while evaporation was measured daily using the pische evaporometer. Water yield was measured in meters, using calibrated staff gauge. Data for rainfall, temperature and evaporation were obtained from 1993-2012 (20 years). Water yield data was also obtained from 1993-2012.

Technique for Data Analysis

Descriptive and inferential statistics were used to analyze the data. The mean, standard deviation and the coefficient of variability as well as correlation and multiple regression analysis were employed to test the relationship between the dependent and independent variables (climate parameters and water yield).

Multiple regression model is given as :

$$Y = a + X_1 b_1 + X_2 b_2 + X_3 b_3 + e$$

Where Y= Water Yield

a = intercept or constant

X_1 = Rainfall

X_2 = Temperature

X_3 = Evaporation

e = the stochastic error or proportion of unexplained

Where Y= Dependable variable

X_1 X_2 X_3 = Independent variables

Discussion of Findings

Tables 1 and 2 shows the mean and standard deviation of the three climatic parameters used in the study. The annual rainfall for Obudu for the period 1993-2012 was 2053.99mm with standard deviation of 504.68 and coefficient of variation of 25%. The mean temperature for the period 1993-2012 was 33.4ºc, with standard deviation of 0.39 and coefficient of variation of 1.2%. The mean annual evaporation for the period 1993-2012 was 46.7mm with standard deviation of 9.08 and coefficient of variation of 5%. Figures 2, 3 and 4 shows trend of departure from the mean for three climatic parameters (rainfall, temperature and evaporation) for the period under review.

Rainfall and Water Yield

Data on annual rainfall and water yield are found in Table 2. This shows inter-annual variation in annual rainfall and water yield from 1993 - 2012. The results revealed an increase in rainfall corresponding with increase in water yield. In 1993, rainfall was 1597.2mm and in 1994 it was 1706.5mm (11% increase). And in the same vein, water yield in 1993 increased from 79.3m to 98.1m in 1994 (19% increase). This pattern of increase in annual rainfall and water yield reflects throughout the period under review (1993-2012).

Table 1

Descriptive Statistics

	Mean	Std. Deviation	N
Rainfall	2053.9900	504.68533	20
Temperature	33.3700	.39484	20
Evapo	46.5700	8.68750	20

Source: Authors' field Analysis 2013 (SPSS Version 17.0)

Table 2

Annual Rainfall, Temperature and Evaporation in 0budu for the period 1993-2012(20 years): mean, standard deviation and coefficient of variation

S/N	Year	ANNUAL RAINFALL(mm)	TEMP (^{O}C)	EVAPORATION (mm)	WATER L. (m)
1	1993	1597.2 (22.2%)*	32.7 (5%)*	43.3 (7.2%)*	79.3(8.8%)*
2	1994	1706.5 (6.9%)*	32.8 (1%)*	40.3 (13.7%)*	98.1(29%)*
3	1995	2180.5 (6.1%)**	33.1 (0.8%)*	39.8 (14.7)*	117.1(7.01%)*
4	1996	1532.5 (25%)*	33.2(0.5%)*	36.3(22.2%)*	88.1(19.9)%*
5	1997	2239.8 (4%)**	32.8 (1.7%)**	39.7(14.9)*	112.3(2%)**
6	1998	2150.4 (4.6%)**	33.9 (1.4%)**	50.1 (7.2%)**	113.0 (2.6%)**
7	1999	1698.6 (17%)*	33.8 (1.1%)**	44.7 (4.2%)**	76.5(30.4%)*
8	2000	1712.7 (16.6)*	33.1 (0.8%)*	59.2(26.7%)**	100.2(8.9%)*
9	2001	1251.4 (39)*	33.3 (0.2%)*	77.6 (66%)**	79.1(28.1%)*
10	2002	2220.7 (8)**	33.4 (0.0%)	47.1 (0.8%)**	130.6(18.6%)**
11	2003	1815.8 (11.5)*	33.7 (0.8%)**	45.3 (2.9%)*	92.6(15.8%)**
12	2004	1523.9 (25.8)*	33.6 (0.5%)**	45.5(2.5%)*	67.0(39.1%)*
13	2005	1781.6 (13.2)*	33.5 (0.2%)**	48.4 (3.6%)**	85.2(22.5%)*
14	2006	1816.3 (11.5)*	33.8 (1.1%)**	45.8 (1.9%)*	93.9 (14.6%)*
15	2007	2373.1 (15.5)**	33.4 (0%)***	46.6 (0.2%)*	129.2(17.3%)**
16	2008	2354.7 (14.6)**	33.5 (0.29%)**	46.3(0.8%)*	133.1(20.9%)**
17	2009	2737.9 (33.3)**	33.7 (0.8%)**	46.4 (0.6%)*	141.6(20.9%)**
18	2010	2398.7 (16.7)**	34.2 (2.3%)**	42.9 ((8.1%)*	129.3(28.6%)**
1 9	2011	2640.2 (28.5)**	33.4 (0%)**	44.0 (5.7%)*	134.2(21.1%)**
20	2012	3347.3 (62)**	33.3 (0.2%)*	42.1 ((.8%)*	200.8(82%)**
TOTAL		41,079.8	667.25	934.0	2201.2
MEAN		2053.99	33.4	46.7	110.06
STDEV		504.68	0.39	9.08	31.08
CV		0.256 (26%)	0.012 (1.2%)	5.143(5%)	28.2%

Source :Authors' field analysis (2013) N/B *Percentage departure below normal ** percentage departure above normal * normal**

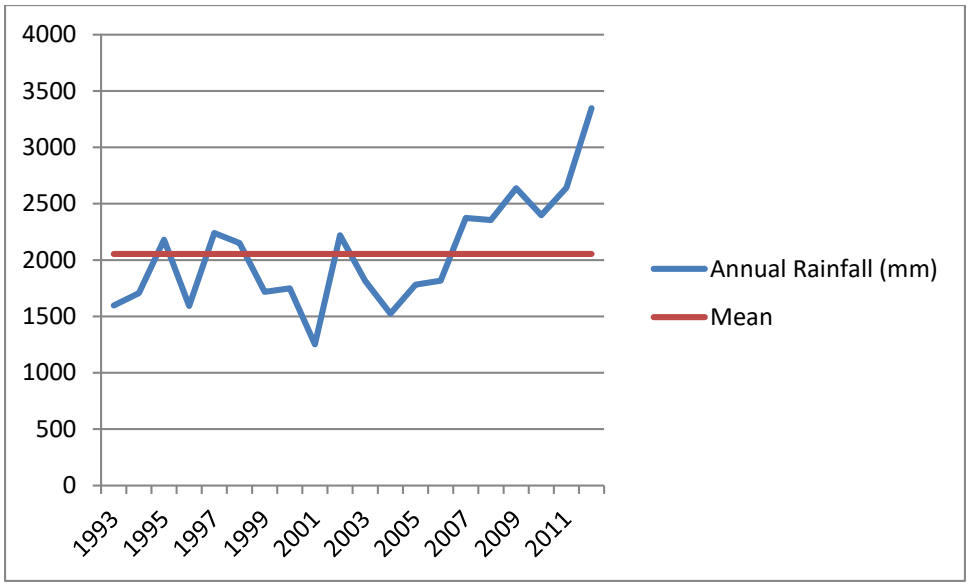


FIG.2 : Trend of annual rainfall (mm) for Obudu (1993-2012), showing departure from the mean

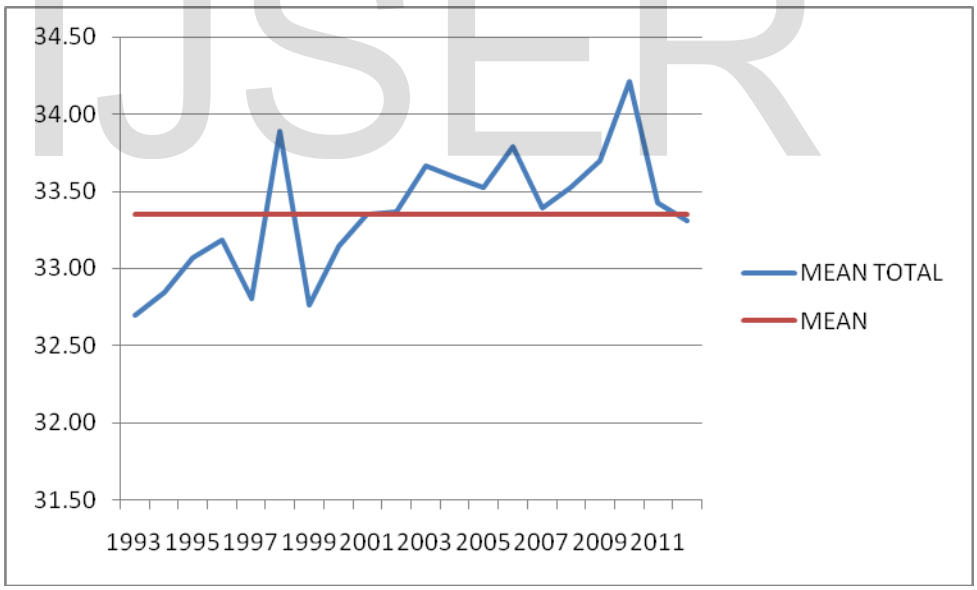


FIG. 3: Trend of mean temperature (^{0}C) for Obudu (1993-2012), showing departure from the mean

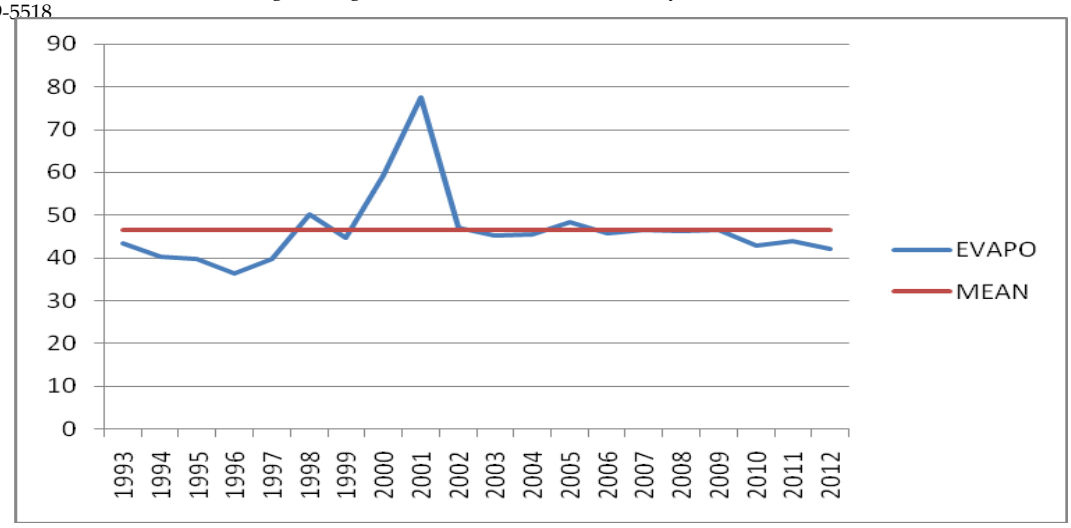


FIG. 4: Trend of mean evaporation (mm) for Obudu (1993-2012), showing departure from the mean

There was also observed decrease in water yield corresponding with decrease in rainfall. In 2000, rainfall was 1712.7mm and in 2001, it decreased to 1251.4mm (39 percent decrease). Water yield in 2000 was 100.2m and in 2001, it decreased to 79.1m(28.1 percent). The lowest negative departure of rainfall and water yield in the series were observed in 2001 and 2004 by 39.0 and 39.1 percent respectively. The findings revealed that the variations in water yield were mainly dependent on rainfall.

Temperature and water yield

Table 2, also shows the mean temperature and water yield for Obudu. Between the period 1993-2001, the temperature departure below mean were (5.0, 1.0, 0.8, 0.5, 1.7, 1.4, 1.1, 0.8, and 0.2% respectively), while the period 2003-2011 showed departure above mean of (0.8, 0.5, 0.29, 1.1, 0, 0.29, 0.8, and 2.3 % respectively). Similarly, between 2007 - 2012, water yield had a departure above mean of 17.3, 20.9, 28.6, 17.4, 21.9, and 82% respectively. While rainfall increases water yield, temperature and evaporation decreases water yield; corroborating with the findings of Utang *et al.,* (2008) who examined the implications of climate variability in the inter-annual and maximum stream flow for flood recession agriculture in Aya basin in Obudu and observed that temperature above normal in some years corresponded with high yield. In 1993, the highest negative departure of 5% was observed and computed. In the year 2010, 2.3% positive departure above normal was recorded.

Evaporation and water yield

The analysis of evaporation and water yield in Table 2 indicates that in the year 1996, evaporation recorded approximately 22.2 % lowest departure below normal and in 2001 it had highest positive departure of 66 %. While water yield recorded 82% positive departure from normal in 2012, with the lowest negative departure of 39.1% in 2004.

TABLE 3

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics					Durbin-Watson
					R Square Change	F Change	df1	df2	Sig. F Change	
1	.965[a]	.931	.918	8 .89188	.931	72.036	3	16	.000	2.269

a. Predictors: (Constant), Evapo, Temperature, Rainfall

a. Dependent Variable: Water yield.

Source : Authors' field analysis 2013(SPSS version 17.0)

TABLE 4

Regression Coefficients[a]

	Unstandardized Coefficients		Standardized Coefficients		
Model	B	STD Error	Beta	T	Sig
1(constant)	102.227	178.191	-	.574	574
Rainfall	0.63	.005	1.018	13.795	.000
Temp	-4.311	5.493	-.055	-.785	.444
Evap	.492	.259	.137	1.896	.076

Source: SPSS VERSION 17.0

The results from the analysis further revealed a co-efficient of multiple determination R^2 of 0.918. This implies that 92% of dependent variable Y (water yield) in River Abeb was accounted for by rainfall variability. The remaining 8% of explanation may be attributed to other factors.

Furthermore, since the calculated t-value of 9.945 is greater than the tabulated t-value of 2.10, this implies that there is significant effect of rainfall variability on water yield. In Table 4, standardized and unstandardized coefficients of the regression model are shown and the equation is given as;

$$Y = 102.227 + 1.018x_1 – 0.55x_2 – 0.137x_3 + e$$

Given a unit increase in rainfall (x_1), water yield (y) will increase by 1.018 units, if temperature (x_2) and evaporation (x_3) are constant. Given a unit measure in temperature (x_2), y will decrease by-0.55, while rainfall (x_1) and evaporation (x_3) are kept constant. Finally, in the model, given a unit increase in x_3 (evaporation), y will also increase by 0.137 units, holding rainfall (x_1) and temperature (x_2) constant. The result in Table 4 shows that rainfall and evaporation are significant while temperature is insignificant.

Table 5: Correlations between water yield, rainfall, temperature and evaporation

		Wateryield	Rainfall	Temperature	Evapo
Pearson Correlation	Wateryield	1.000	.957	.206	-.230
	Rainfall	.957	1.000	.236	-.353
	Temperature	.206	.236	1.000	.145
	Evapo	-.230	-.353	.145	1.000
Sig. (1-tailed)	Wateryield	.	.000	.192	.165
	Rainfall	.000	.	.158	.063
	Temperature	.192	.158	.	.271
	Evapo	.165	.063	.271	.
N	Wateryield	20	20	20	20
	Rainfall	20	20	20	20
	Temperature	20	20	20	20
	Evapo	20	20	20	20

Table 6: Zero order Correlation Matrix

	Water Yield	Rainfall X_1	Temperature X_2	Evaporation X_3
Water yield	1.00	0.95	0.20	-0.23
Rainfall		1.00	0.23	-0.35
Temperature			1.00	0.14
Evaporation				1.00

Conclusion

The study examined the impact of climate variability on water yield in River Abeb. The results revealed that rainfall was positively correlated with water yield in the region. This implies that increase in rainfall results to high water yield while a decrease in rainfall means low water yield. This scenario is of great importance to water resource institutions like Cross River State Water Board Limited that pump water directly from River Abeb. The study has revealed that River Abeb had the highest water yield in 2012 (with 82% highest positive departure) which was as a result of high amount of rainfall in the same year (2012). Rainfall had the highest positive departure of 62%. The study further revealed that in 2004, River Abeb recorded the lowest negative departure of 39% (lowest in 20 years). The study confirms that there is evidence of rainfall variability. That is, there is variability in rainfall regime in the study area within a period of 20 years. The percentage of variation of each climatic parameters have been ascertained. The study has also shown that there is a strong relationship between rainfall variability and water yield in river Abeb.

It is therefore recommended that there should be restrictions on land use development around River Abeb catchment. Government should provide safety net programme which will enable the citizens living around the river to carry on their economic activities including mining away from the basin catchment. Furthermore, massive aforestation project around the river area is needful to stimulate convection that will bring rainfall generating cloud, hence rainfall to boost water yield. Mechanisms should be put in place to promote synergy on issues relating to water yield, rainfall variability and forest resource management to ensure sustainable water resource management in the study area.

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